Monitoring and Modeling The Water Cycle at Multiple Scales – Getting It Right for the Right Reasons

SARP - Water

Ana P. Barros

NOAA GLERL Workshop , August 27-29 2012

Audit

Planning for adaptation

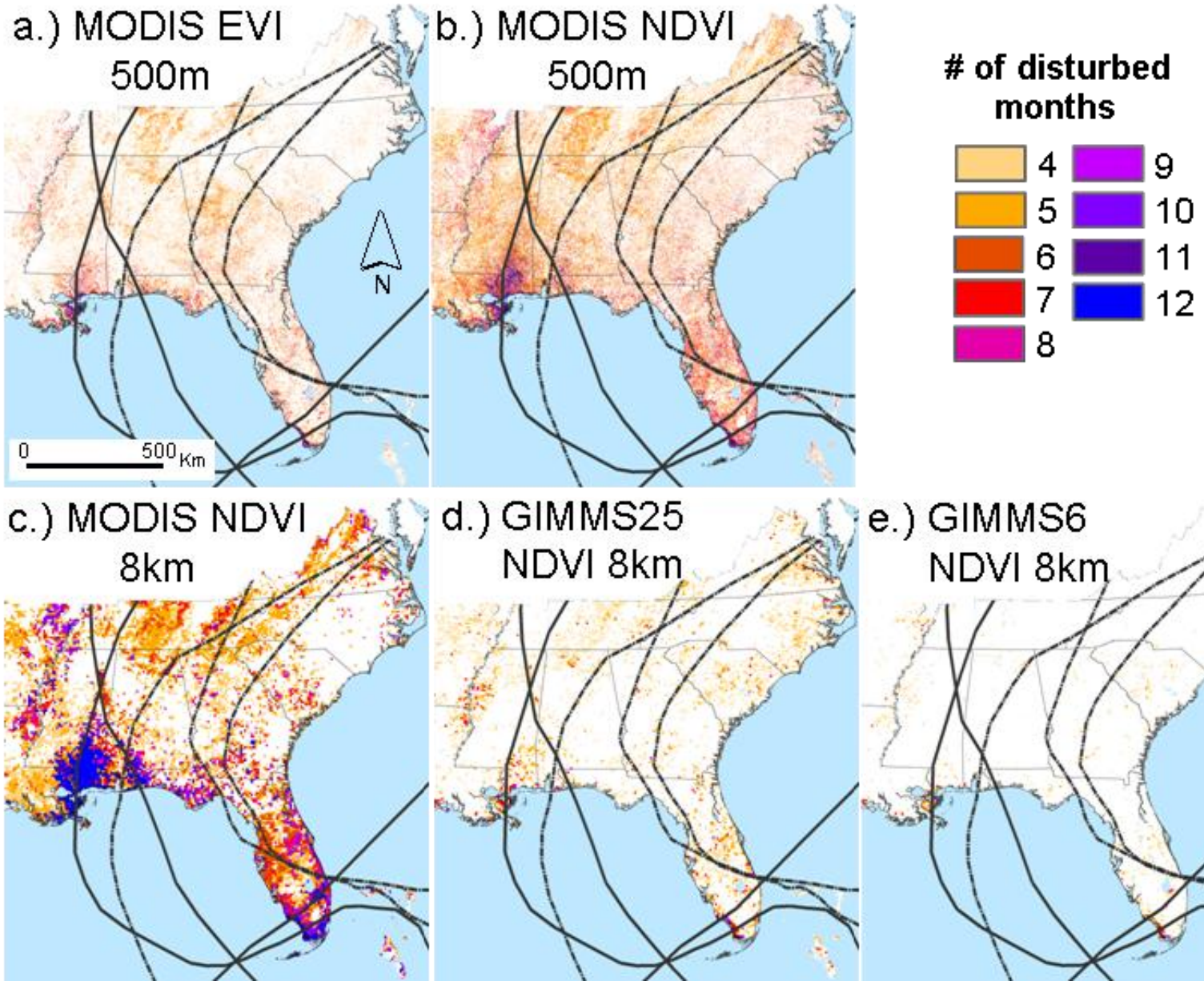
F1: Methods for prioritisation of vulnerabilities in the infrastructure system are needed for effective planning. There will be a need to distinguish between the short term effects of climate change, such as flash flooding, which in some situations may reluctantly have to be tolerated, and those that are sustained or persistent, such as rivers running low, where it may be more realistic to introduce counter measures economically. Not all parts of the country face similar risk levels or similar impacts. Regional maps of severe weather impacts mapped against critical infrastructure elements would be useful.

From "Engineering the Future", UK

- **Severe Impacts**

Outline

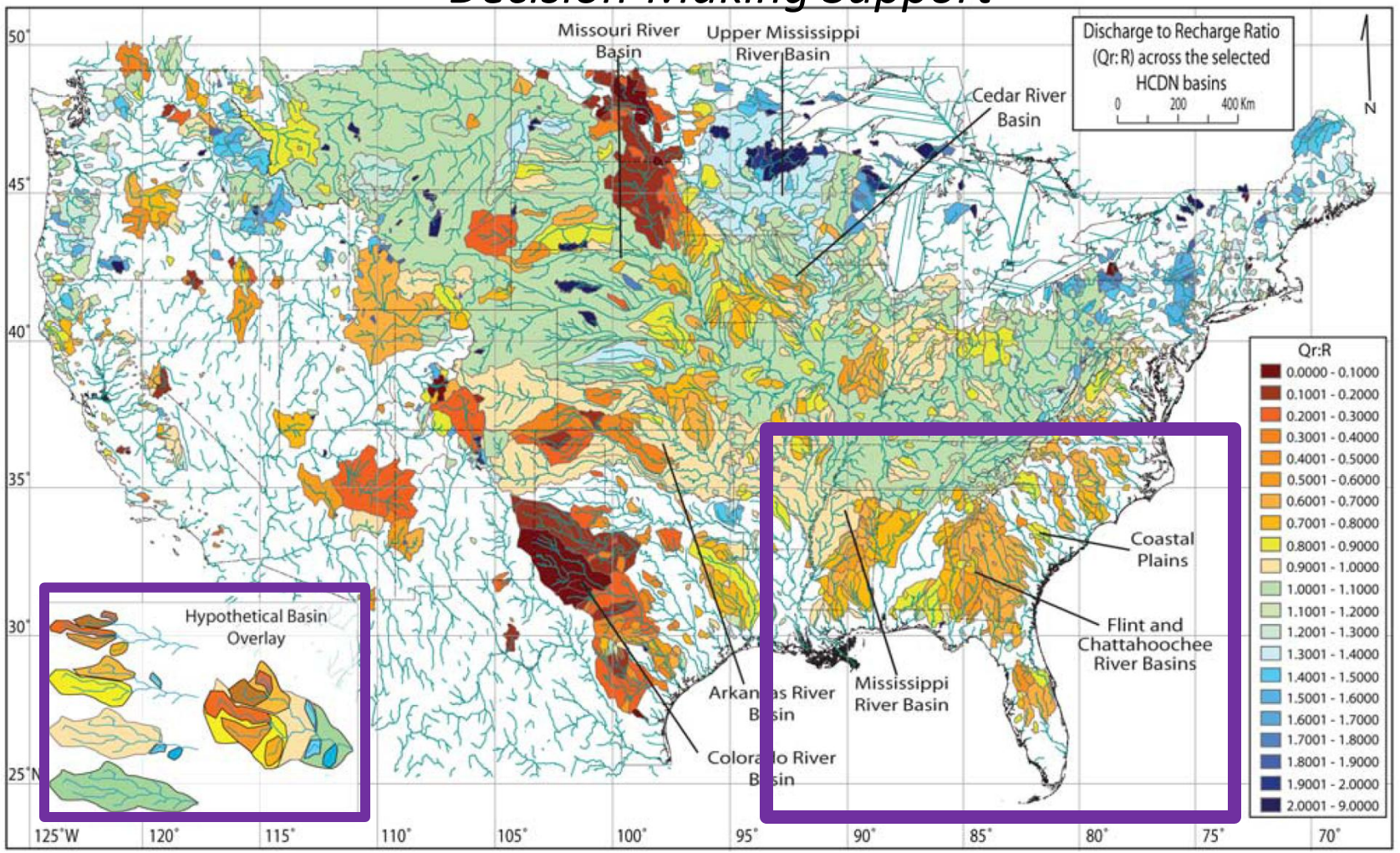
- **Spatial and Temporal Scales of Water Cycle Audits**
  Documenting/Understanding Variability
- High-Frequency Events - Nuisance or Resiliency?
- Light Rainfall - Hydroweaving Functional Landscapes



Brun and Barros 2012a

Regional Multiscale Surface-Groundwater Interactions

Decision-Making Support



Annual Hydroclimatology

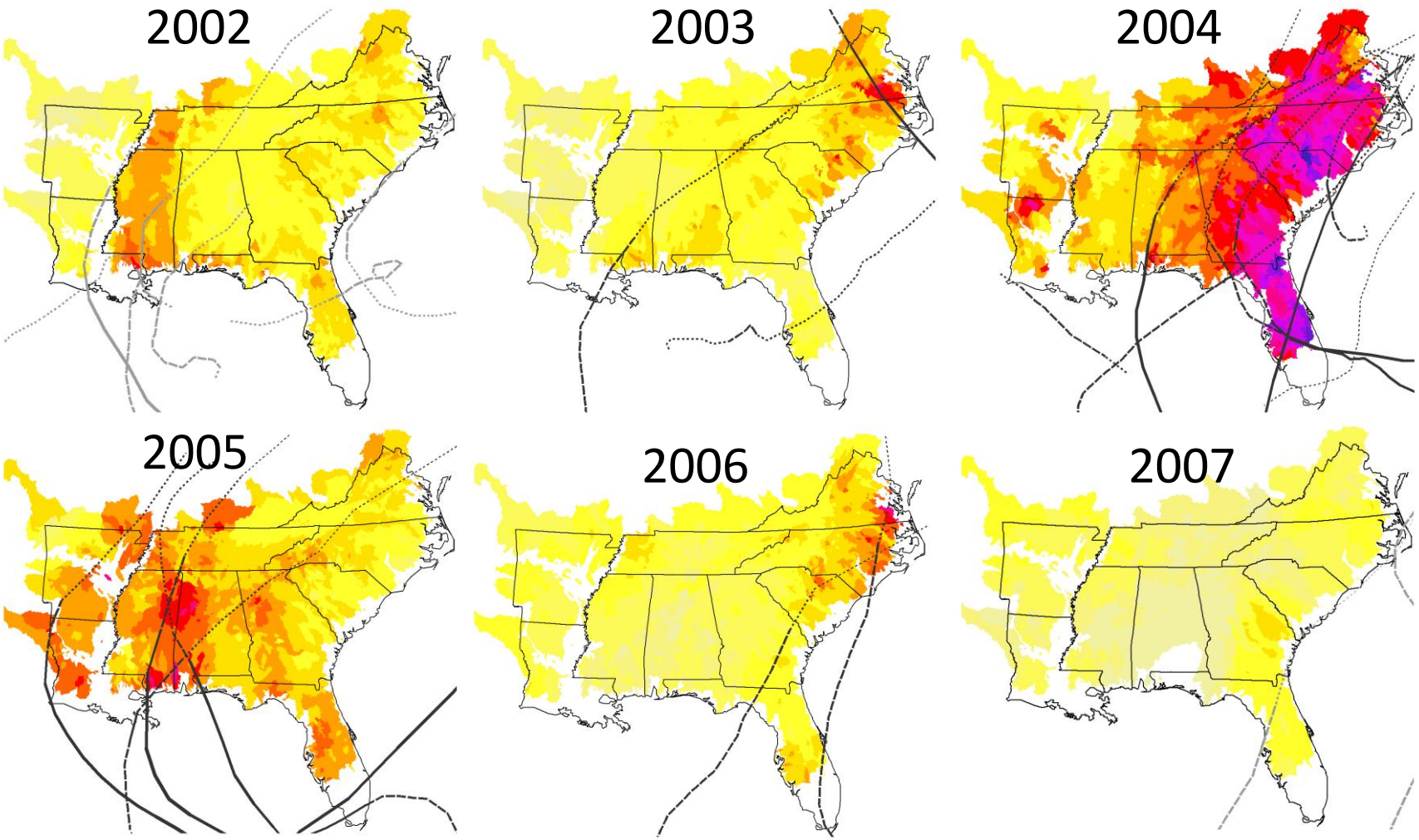
Widespread "Unaccounted" Pumping

P_a ~ 1000-1200 mm/year

$Q_r/(P_a - ET_a)$ ~ 0.5-0.9/1.0

Adapt. Schaller and Fan, JGR 2009

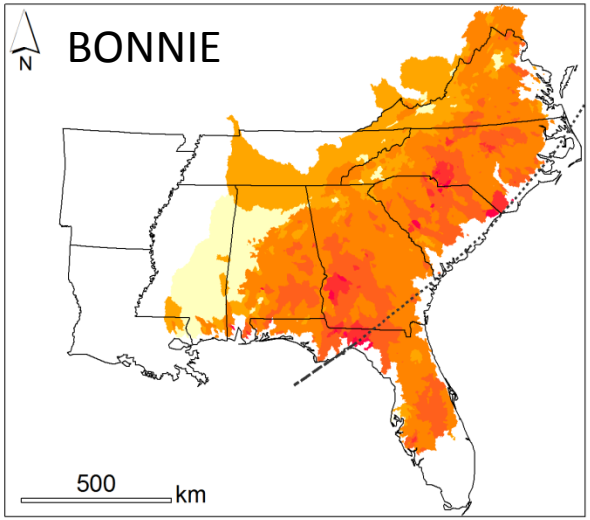
Stage IV Cumulative Precipitation Depth: TC Season Fraction

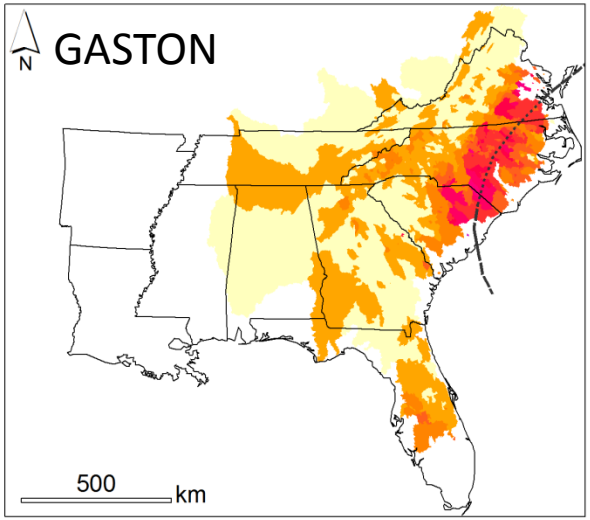


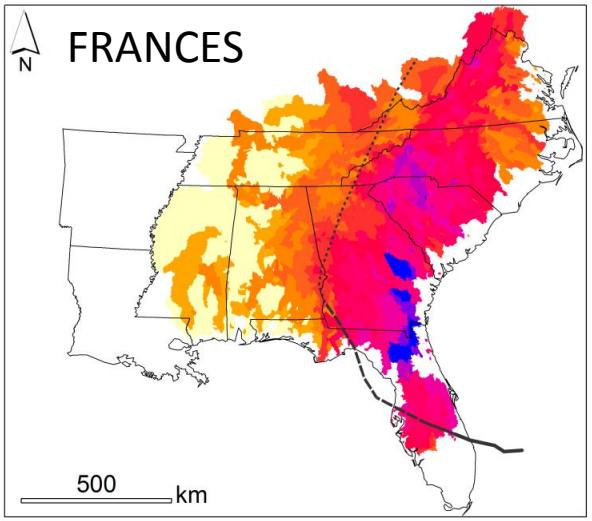
Fraction of Precipitation Produced by TC

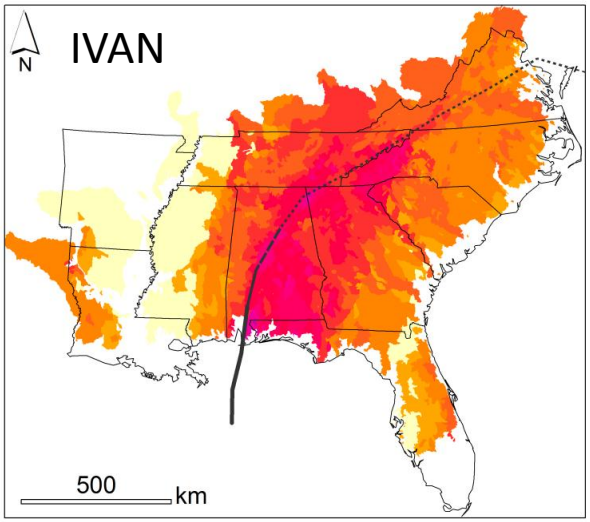
Brun and Barros 2012b

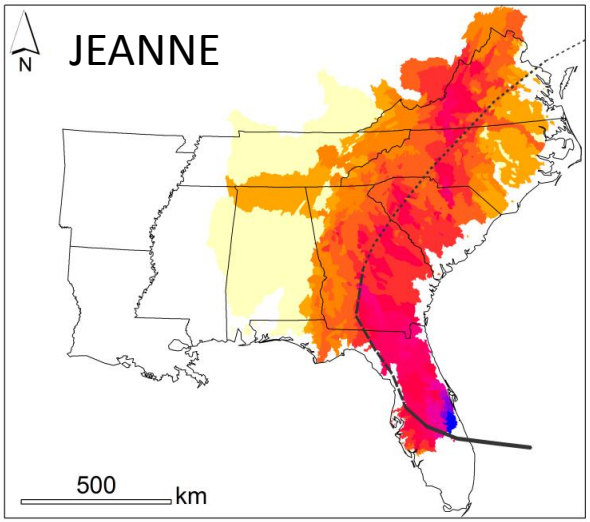
Stage IV Cumulative Precipitation Depth: Specific TC Fraction









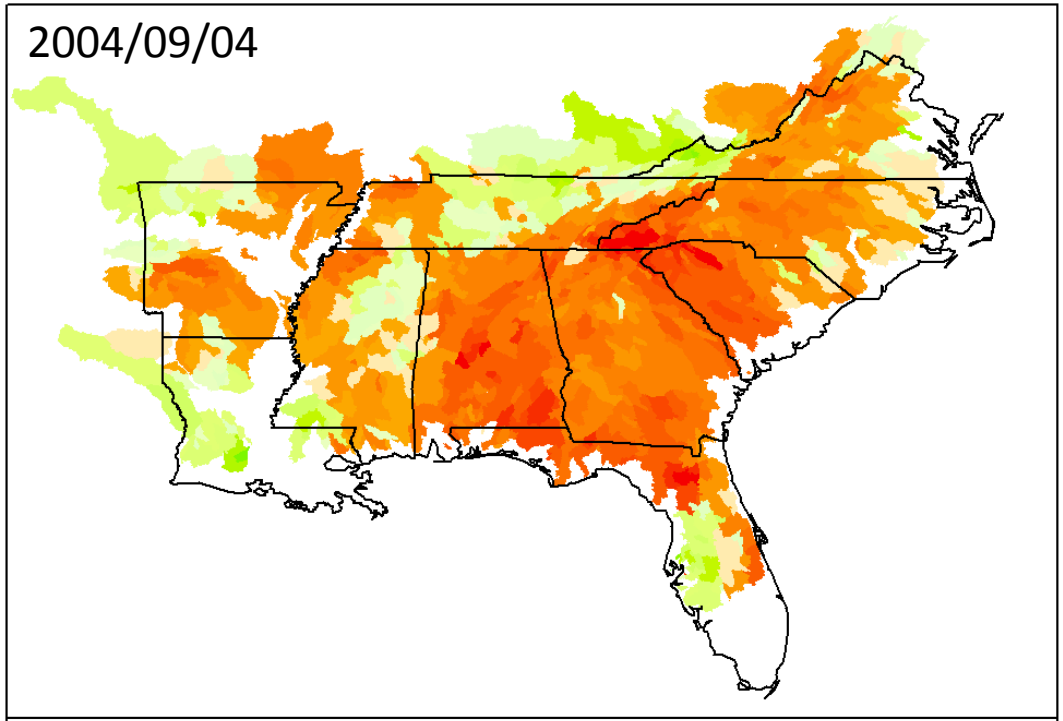


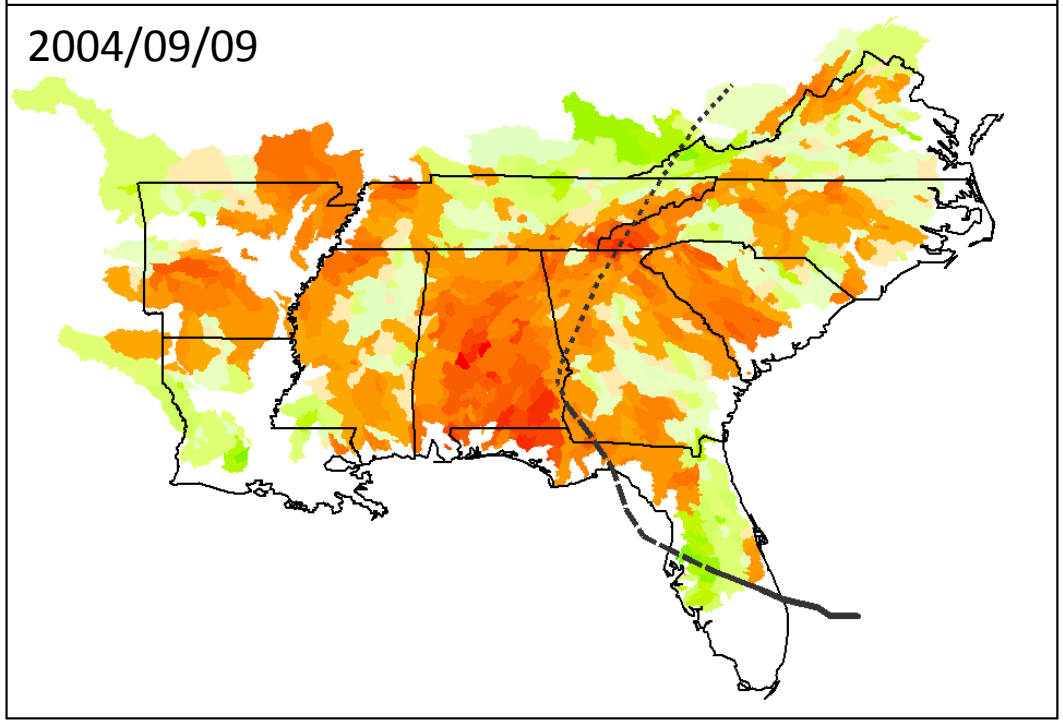
Precipitation Fraction

0 - 1%
1.1 - 2%
2.1 - 4%
4.1 - 6%
6.1 - 8%
8.1 - 10%
10.1 - 12%
12.1 - 14%
14.1 - 16%
16.1 - 18%
18.1 - 20%
20.1 - 22%

Brun and Barros 2012b

2004



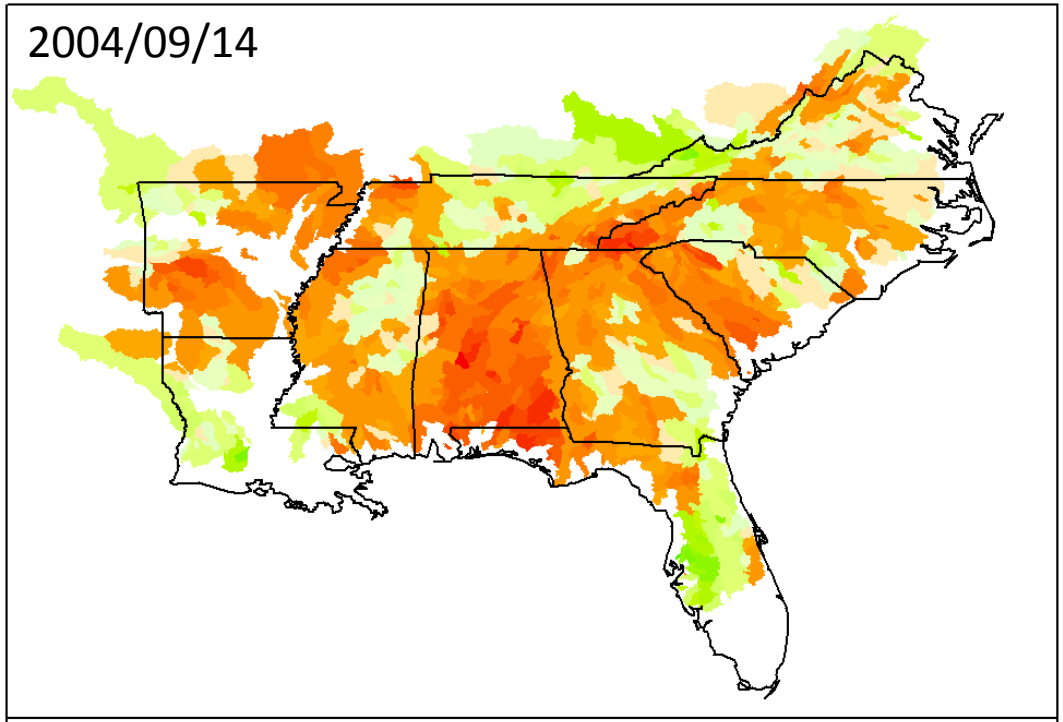


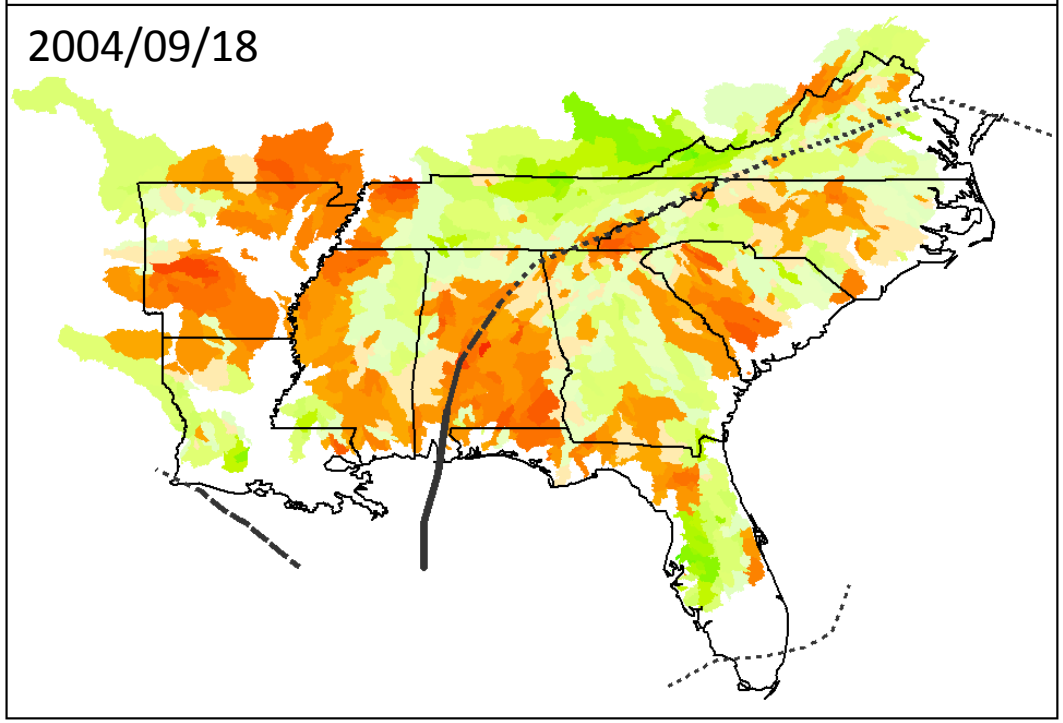
Frances

Precipitation Deficit [mm]

- < -350
- -349 - -300
- -299 - -250
- -249 - -200
- -199 - -150
- -149 - -100
- -99 - -50
- -49 - -25
- -24 - 0
- 1 - 25
- 26 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600
- > 601

Brun and Barros 2012b



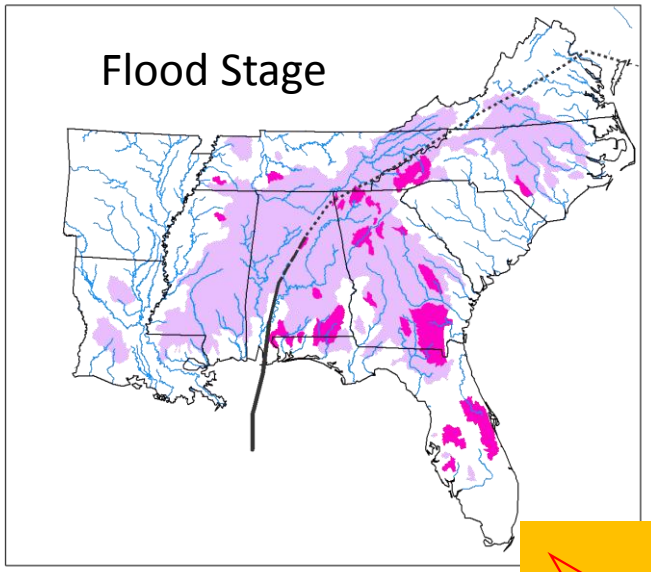


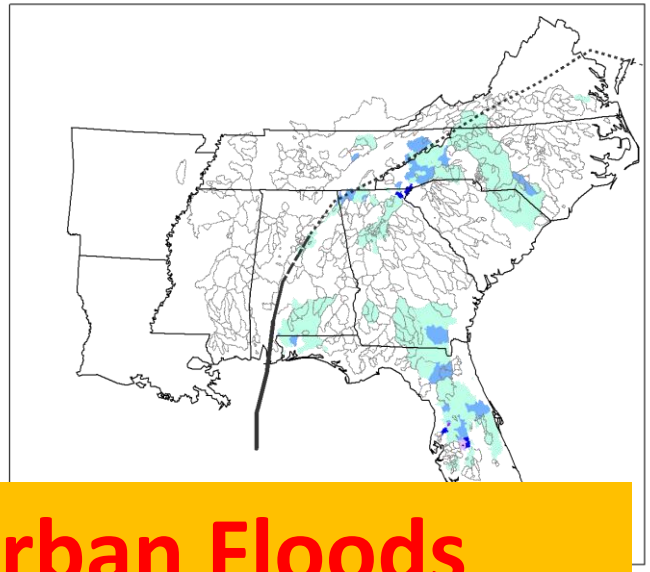
Ivan

Precipitation Deficit [mm]

- < -350
- -349 - -300
- -299 - -250
- -249 - -200
- -199 - -150
- -149 - -100
- -99 - -50
- -49 - -25
- -24 - 0
- 1 - 25
- 26 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600
- > 601

Brun and Barros 2012b



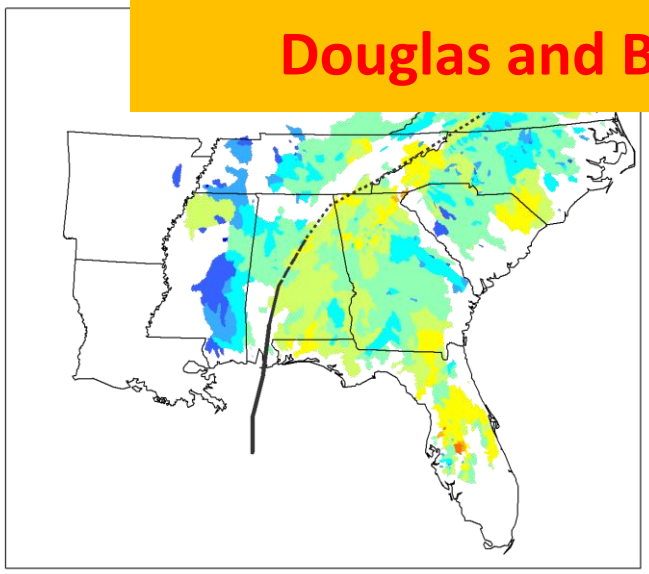


< 2 years
≥ 2 years
≥ 5 years
≥ 10 years
≥ 25 years
≥ 50 years
≥ 100 years

➢ Urban Floods

Douglas and Barros 2002

Ivan



-3.90 - -3.00
-2.99 - -2.00
-1.99 - -1.50
-1.49 - -1.00
-0.99 - -0.50
-0.49 - -0.25
-0.24 - 0.00
0.01 - 0.10
0.11 - 0.25
0.26 - 1.00

Q/Q10

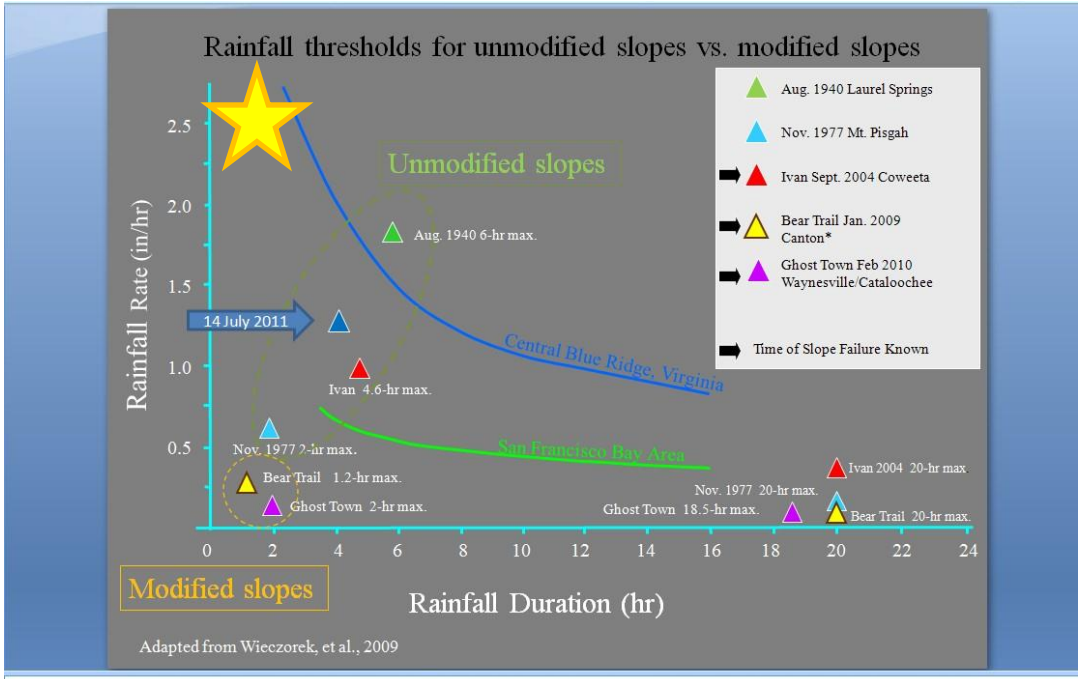
Brun and Barros 2012b

➢ Flash Floods and Debris Flows

Initial Conditions

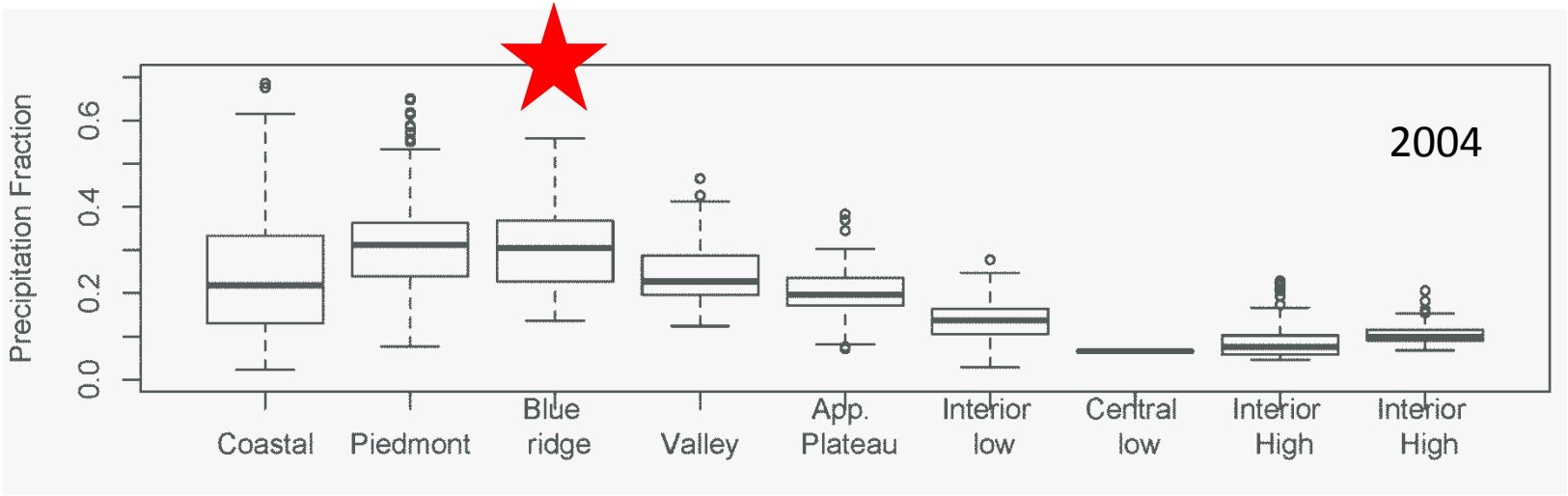
Precipitation Intensity

---- 100m or less

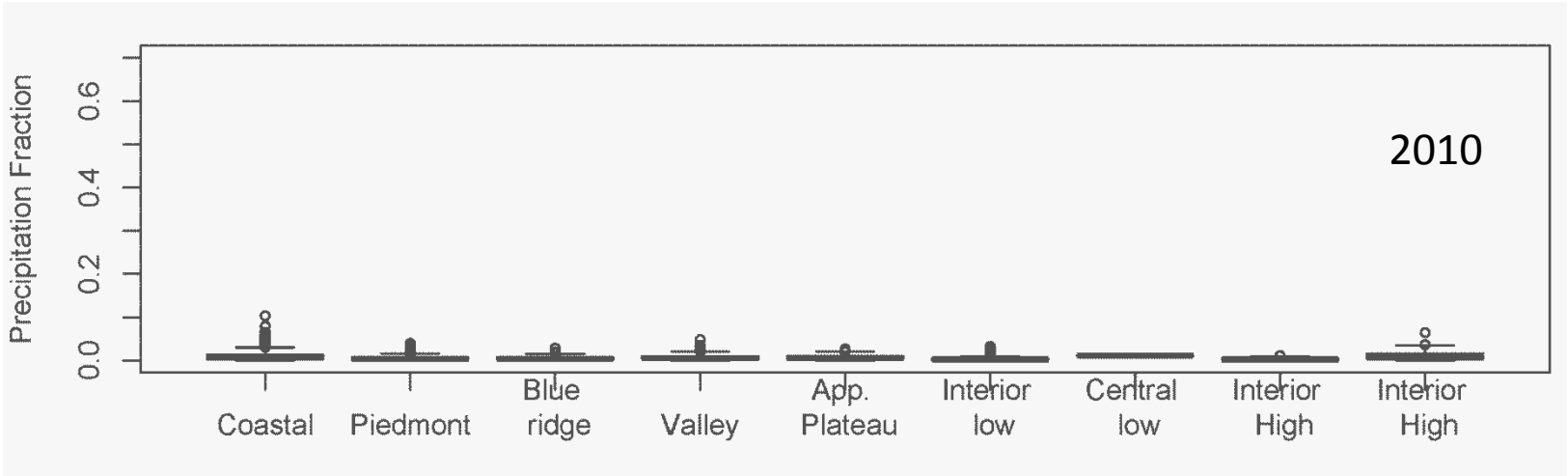


USGS (Wieczorek, et al., 2009) presented curves from numerous data points connecting rainfall intensity and duration to landslide occurrence
NCGS not have the dataset for specific known times of landslide occurrence, but building it.
Limited data from western North Carolina data indicate that rainfall thresholds for modified slopes that are already showing signs of instability – or debris slides turning to debris flows, may be lower than failures on unmodified slopes.

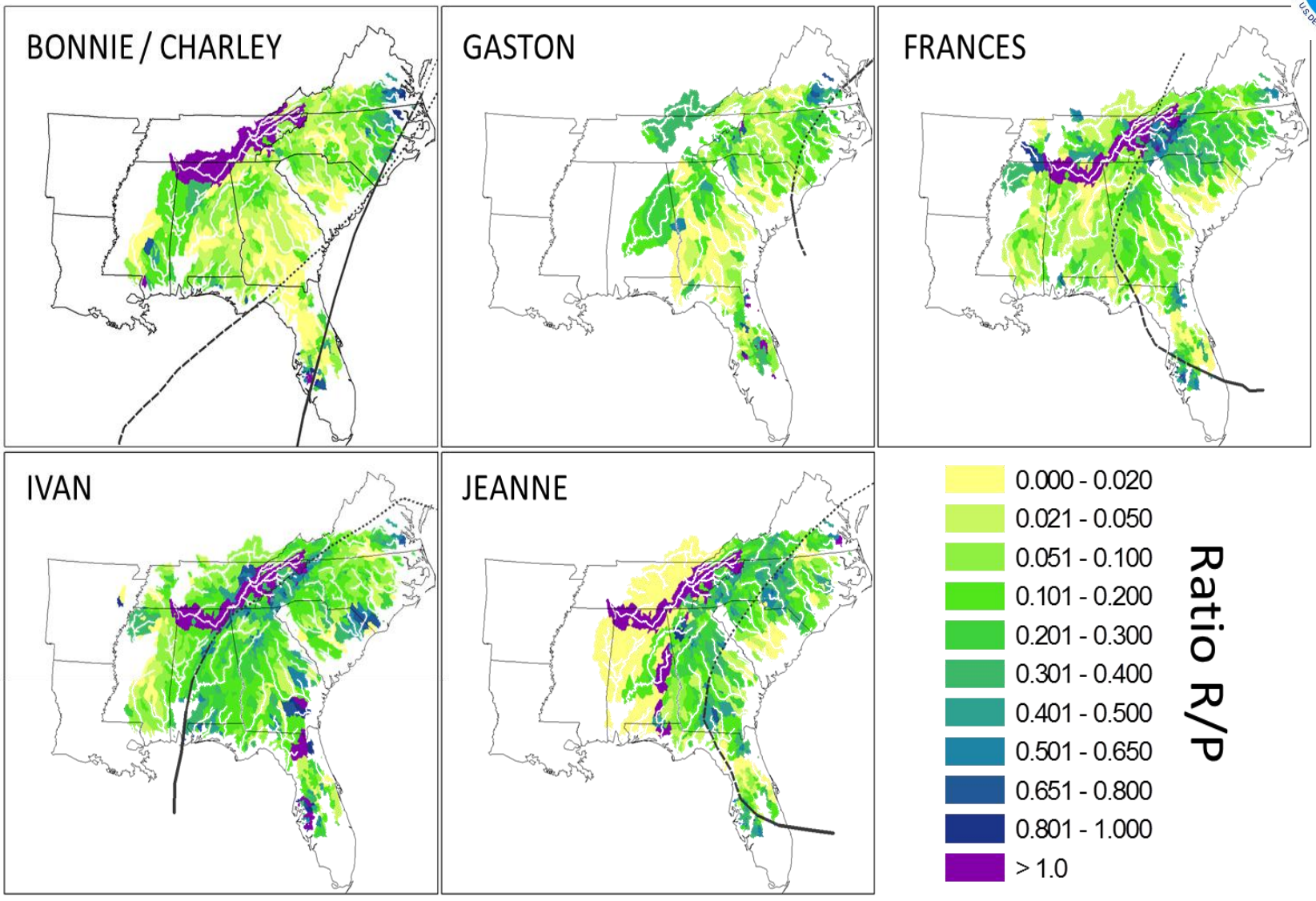
Barros et al. 2012



$$\frac{P_{TC}}{P}$$



Brun and Barros 2012b



Brun and Barros 2012b

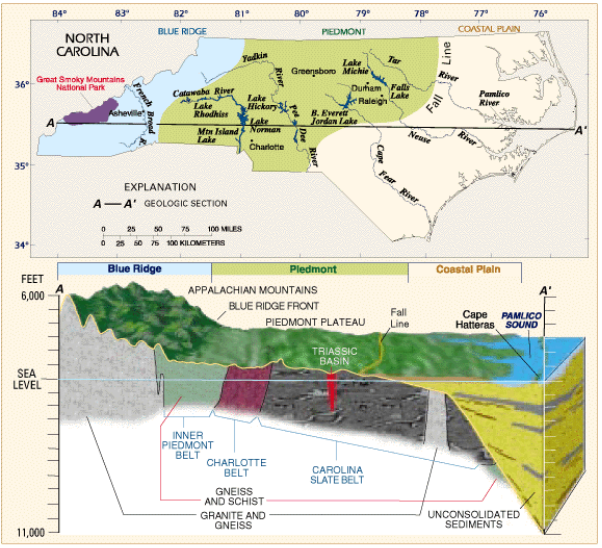
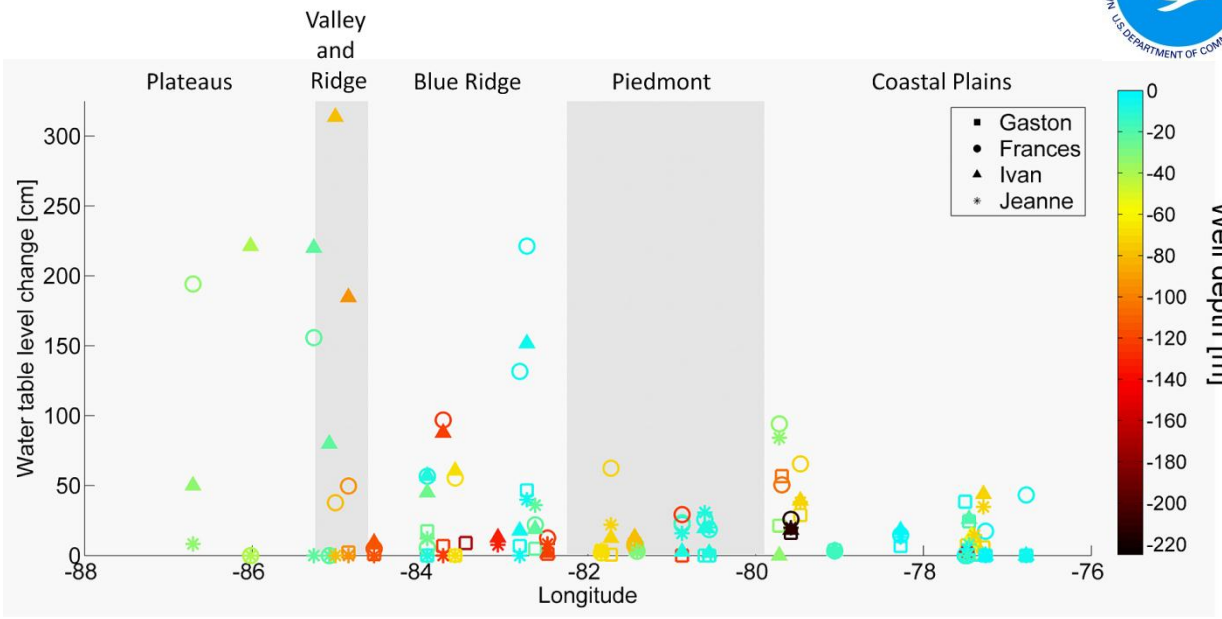
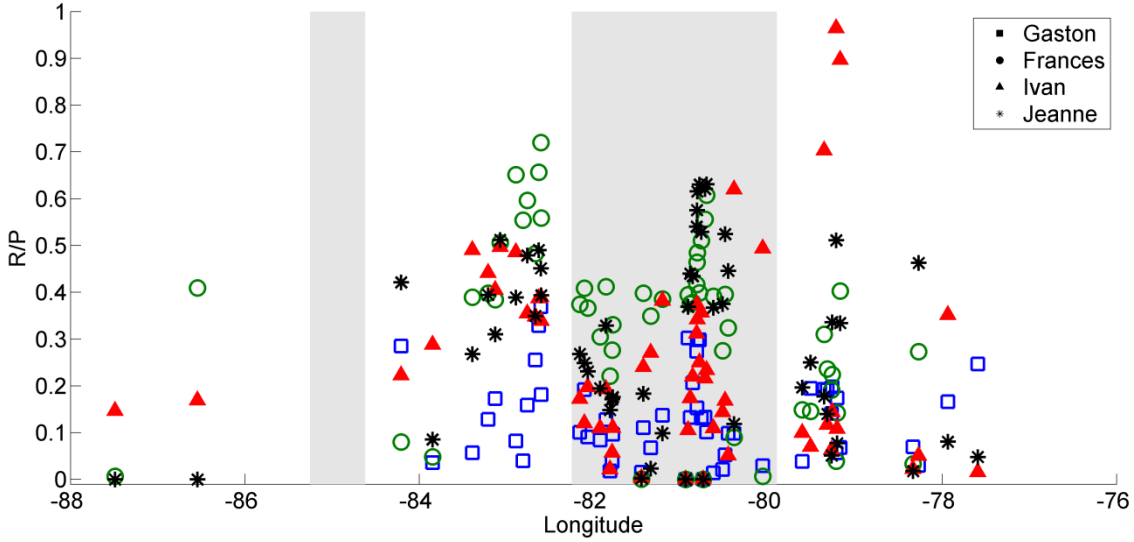


Figure 2. Map of North Carolina and diagrammatic geologic ection of the State.



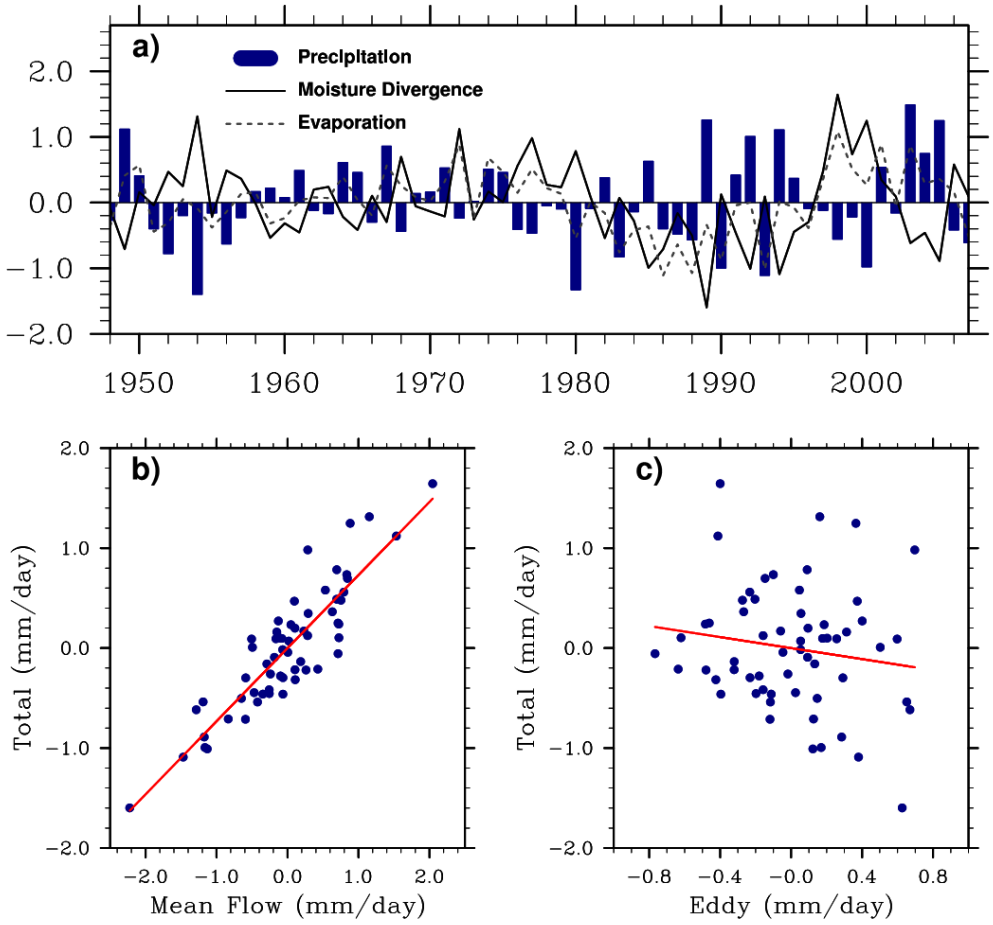


Brun and Barros 2012b

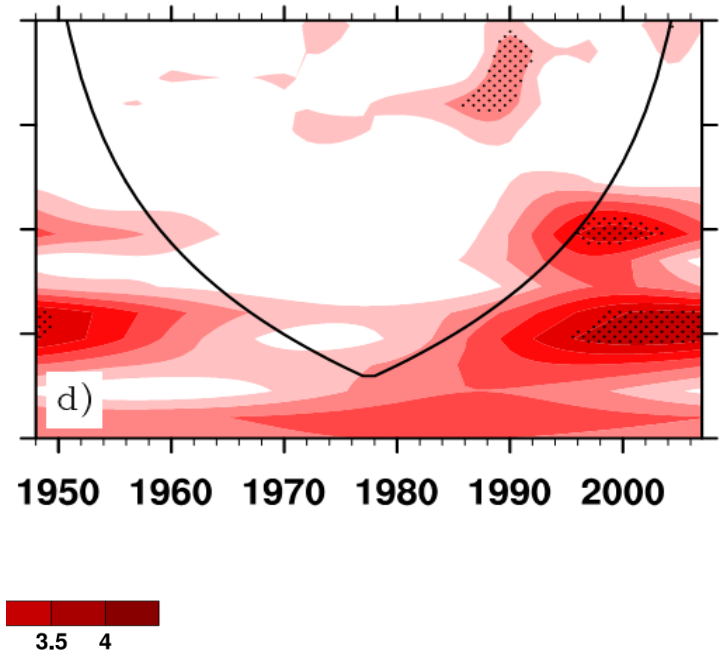
Outline

- Spatial and Temporal Scales of Water Cycle Audits
- **High-Frequency Events - Nuisance or Resiliency?**
- Light Rainfall - Hydroweaving Functional Landscapes

Regional Scale Hydroclimatic Variability

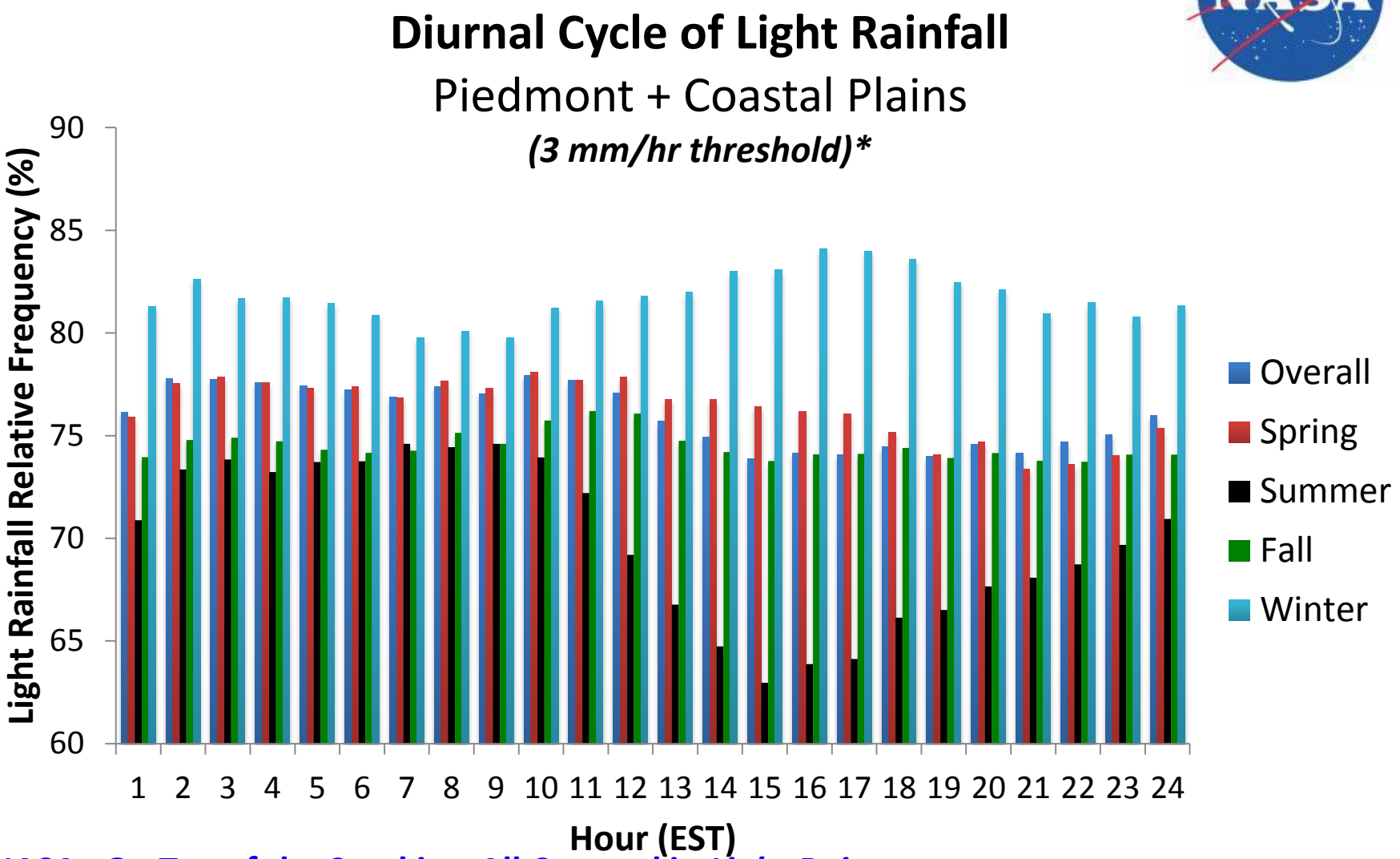


Mean Moist Divergence



Li et al. 2012

Regional Scale



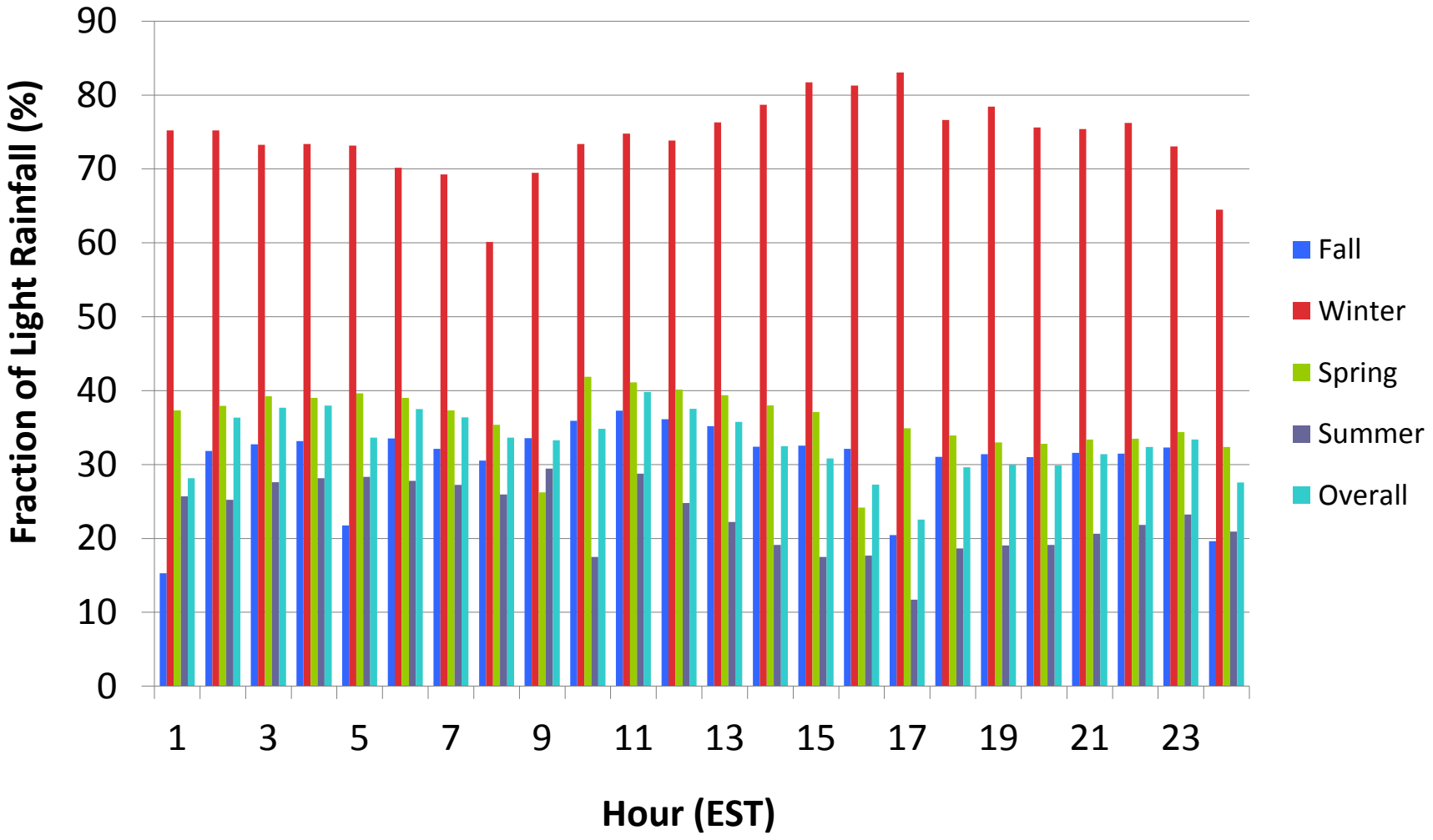
[NASA - On Top of the Smokies, All Covered in *Light Rain*](www.nasa.gov/topics/earth/features/smokies.html)

*www.**nasa**.gov/topics/earth/features/smokies.html*

Barros et al. 2012

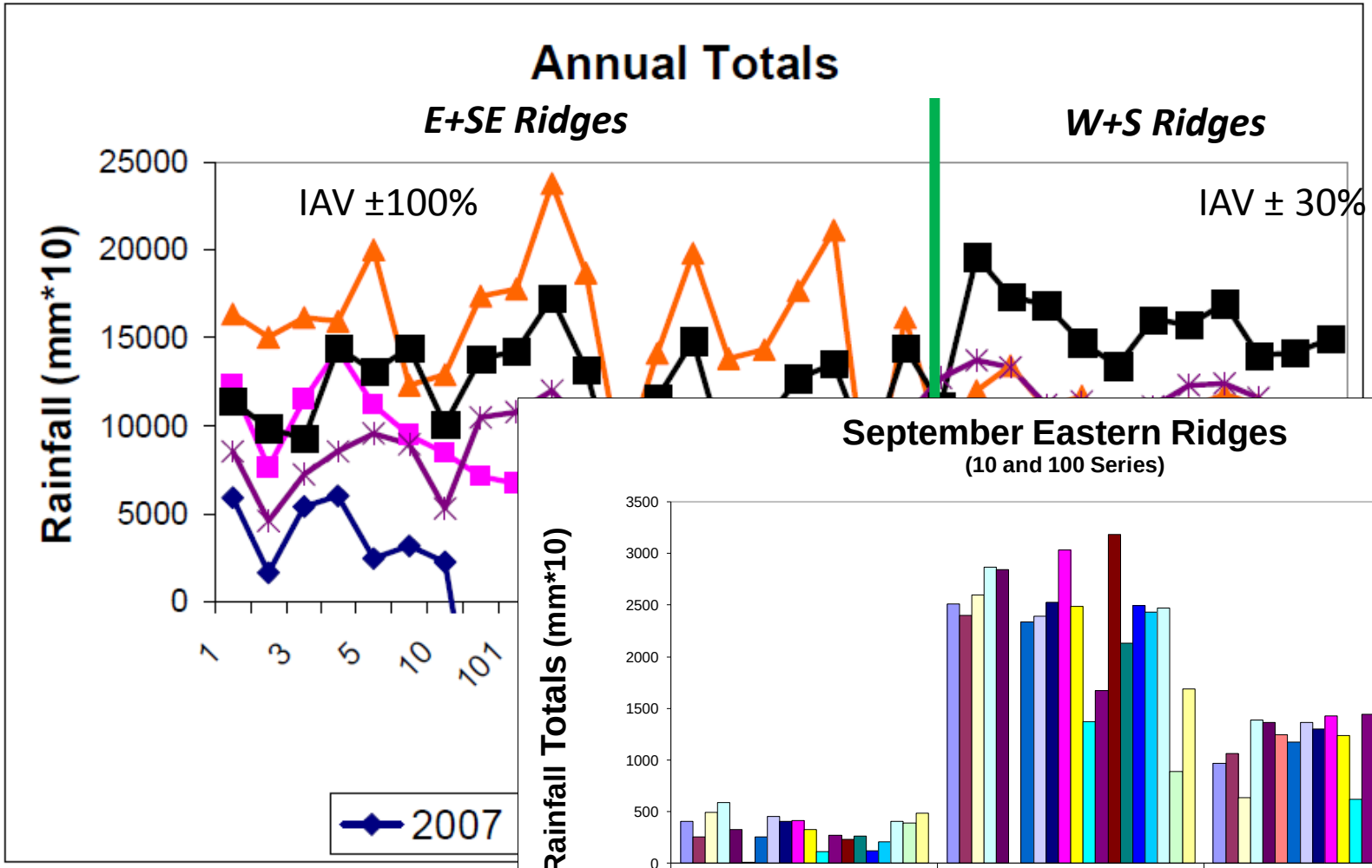
Diurnal Cycle of Light Rainfall - Contribution to Total

Piedmont + Coastal Plain

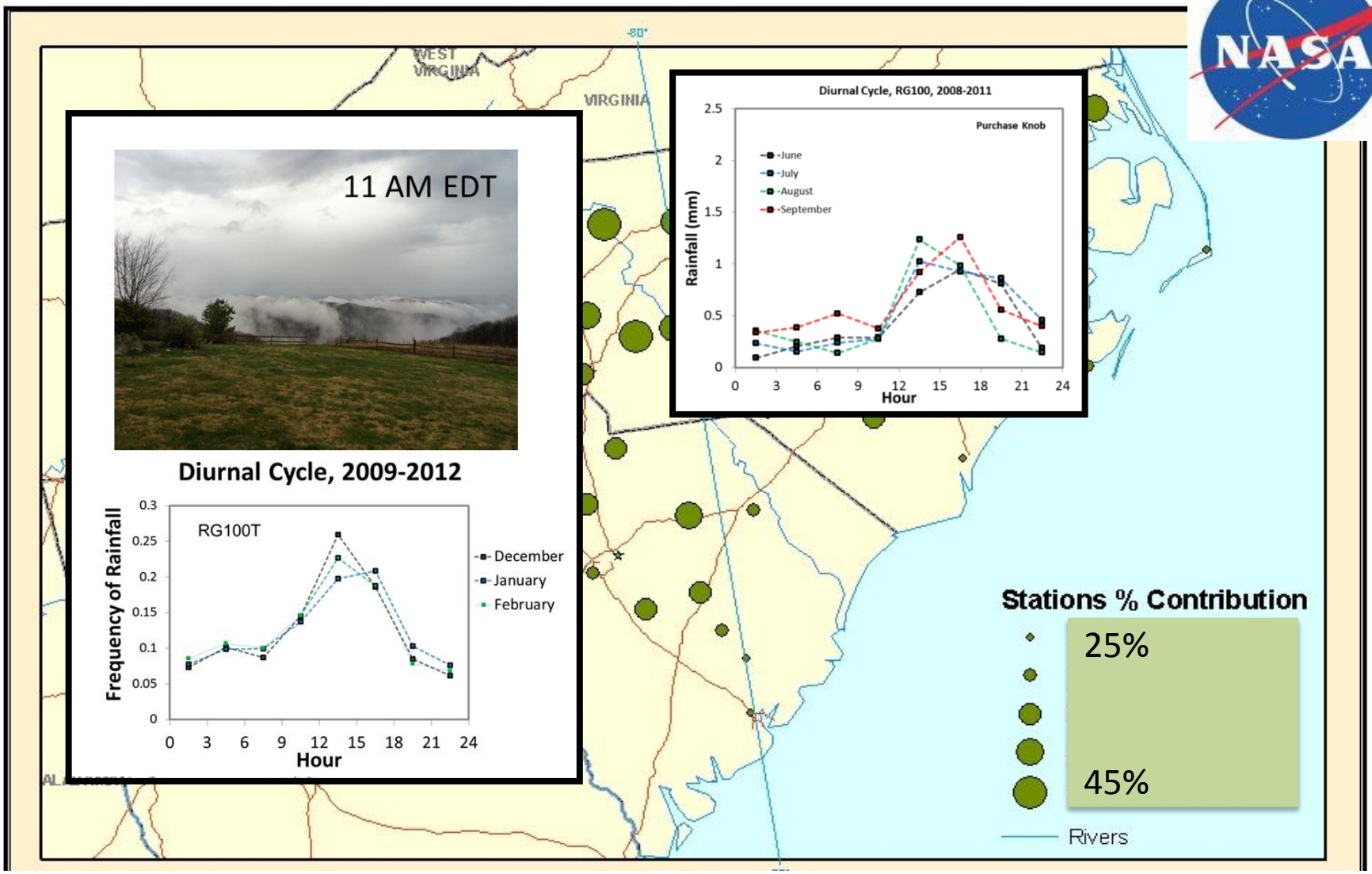


Barros et al. 2012

Appalachians



Barros et al. 2012



Confusing Matters Relatively Sparse "Unplanned" Observations
Raingauge Resolution (0.01" -0.1")

Barros et al. 2012

Outline

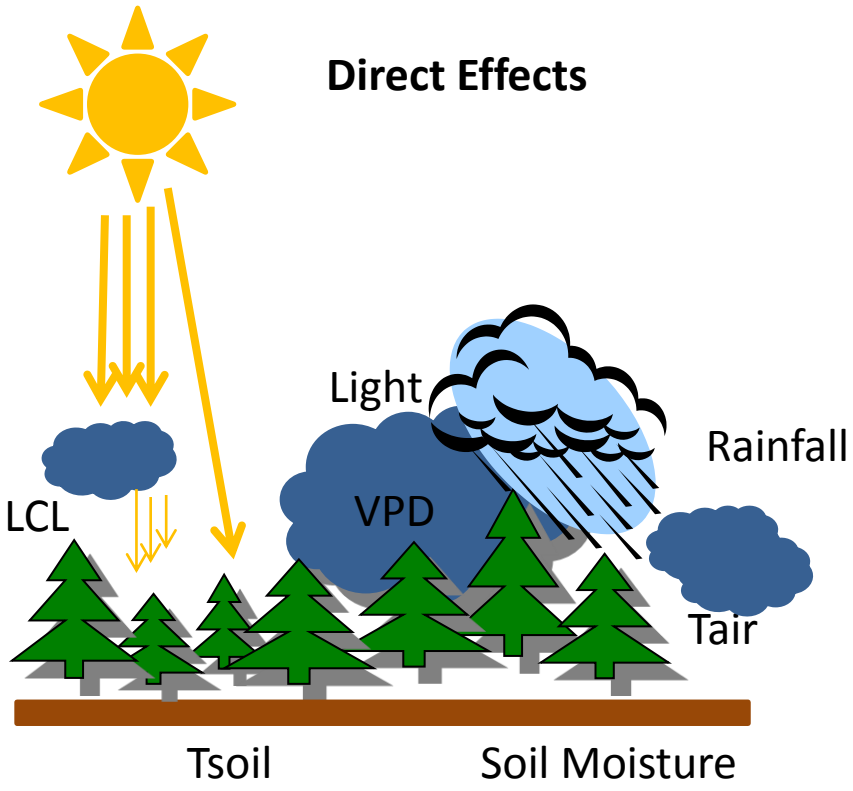
- Spatial and Temporal Scales of Water Cycle Audits
- High-Frequency Events - Nuisance or Resiliency?
- **Light Rainfall - Hydroweaving Functional Landscapes**

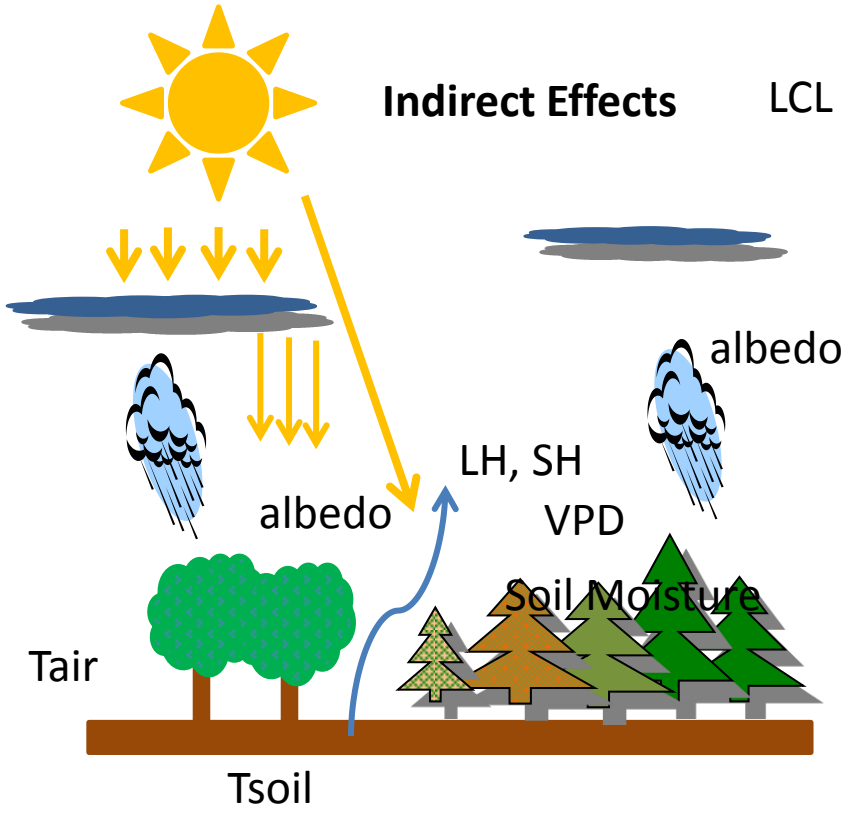
Landscapes as Throughflow Systems

"We suggest… that nitrogen retention hot spots are variable in space and shift in relation to storm size, intensity and frequency."

Fisher et al. 2001***

Fog-Cloud-Rainfall Interactions and the Surface Energy Budget

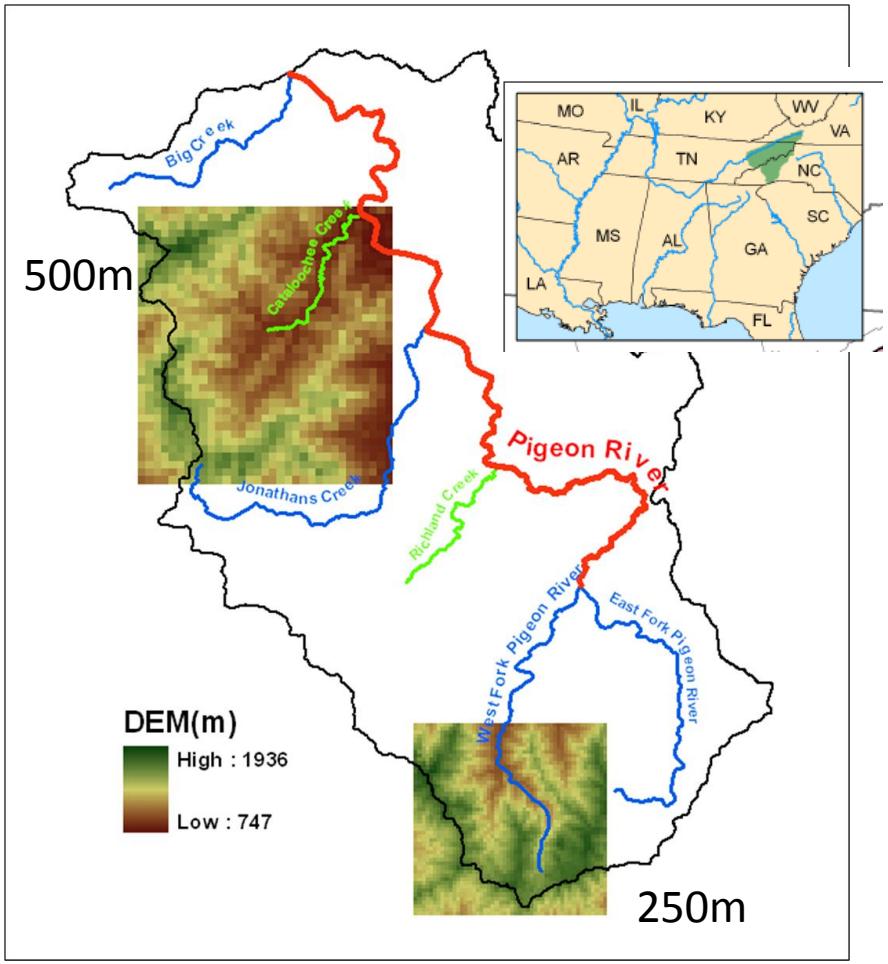


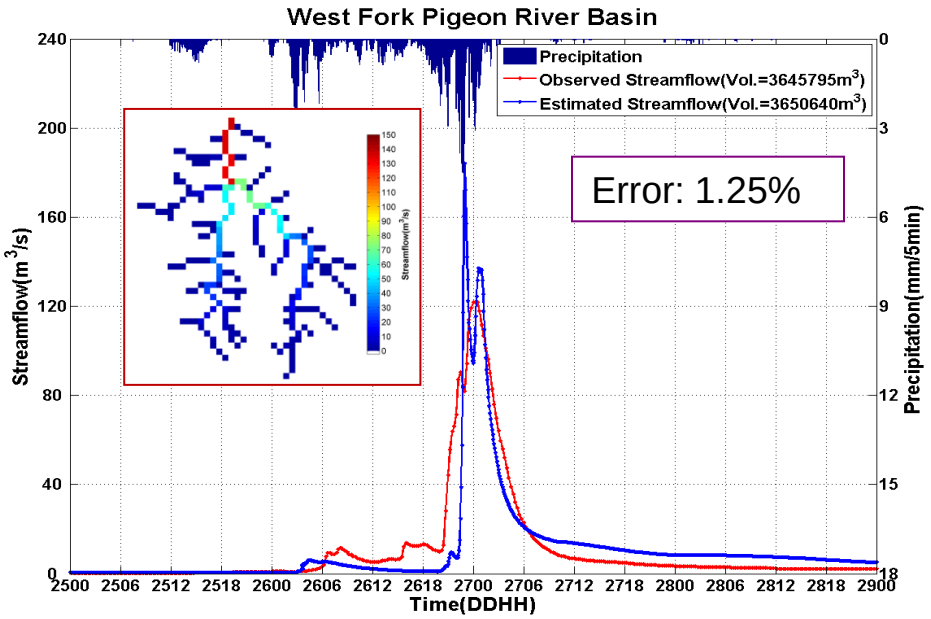


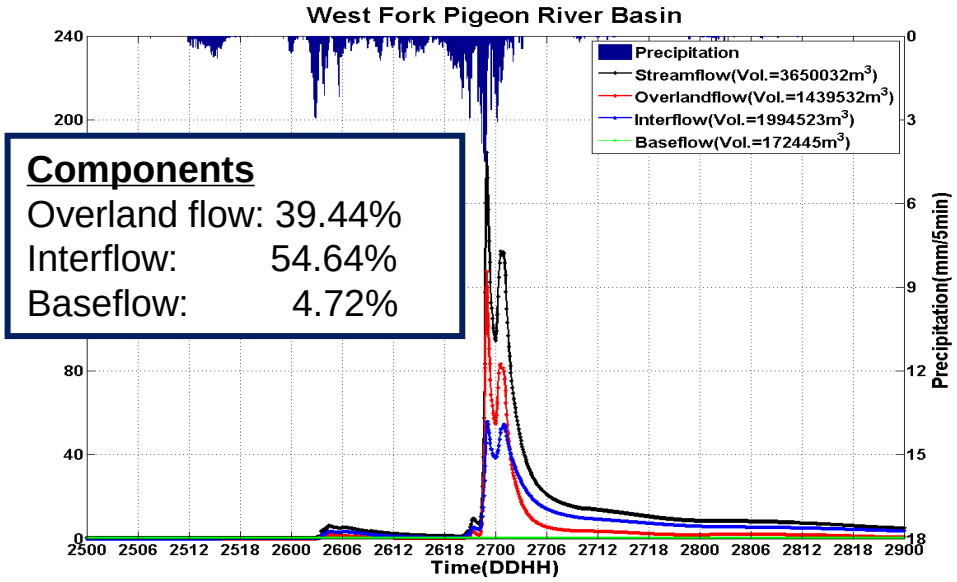
Barros 2012

Flashflood Response

Tropical Storm Fay





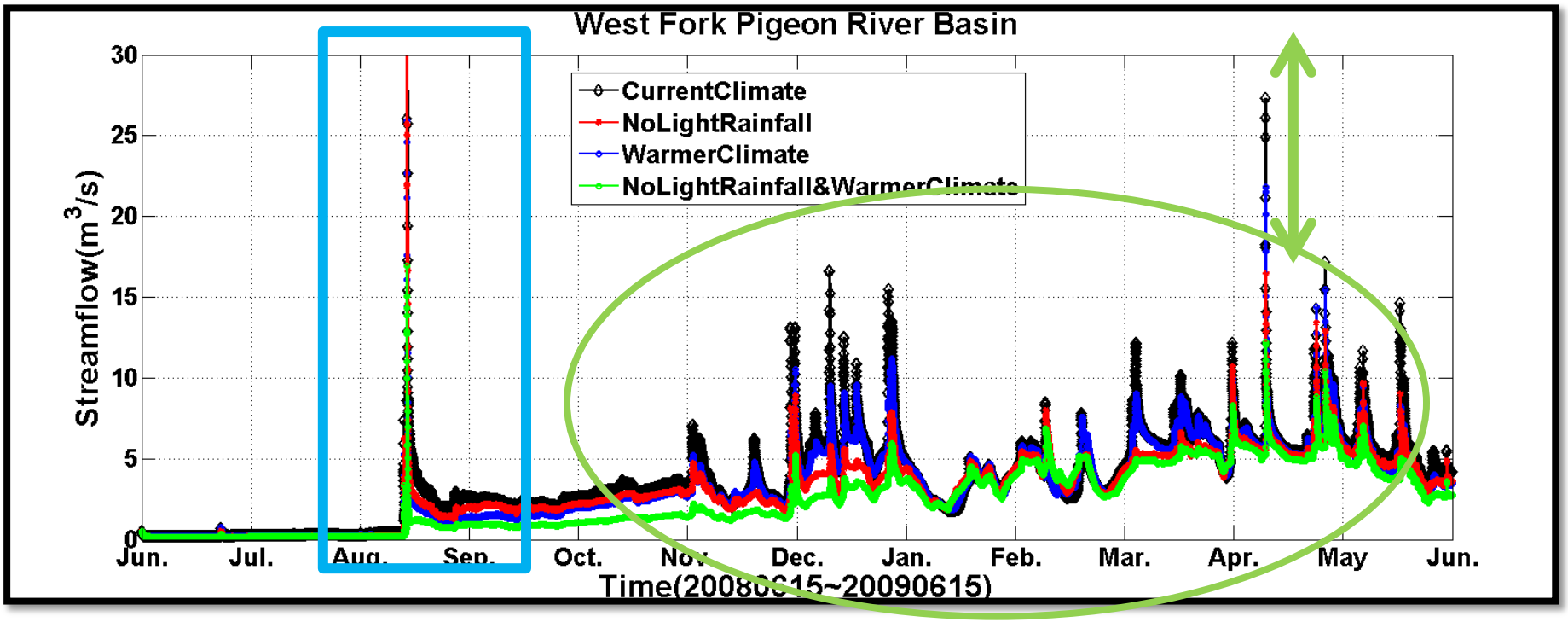


Tao et al. 2011

Hydrologic Regime Response

- Amplitude of the Diurnal Cycle of Temperature
- Light Rainfall Feedback $\Delta T_d = +2^oC$

TS Fay

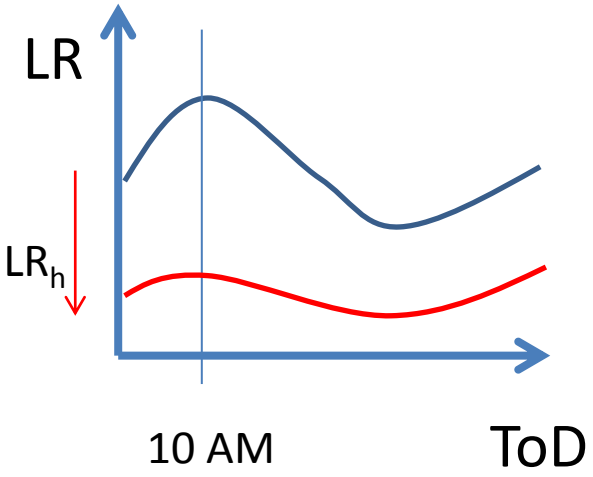


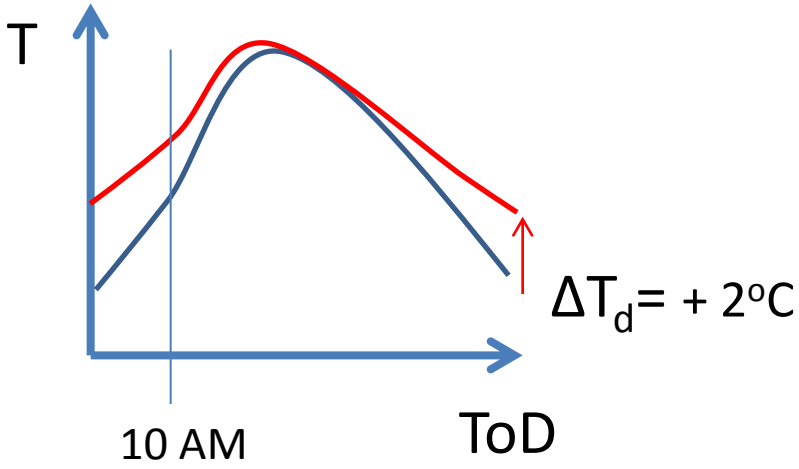
June 2008-June 2009

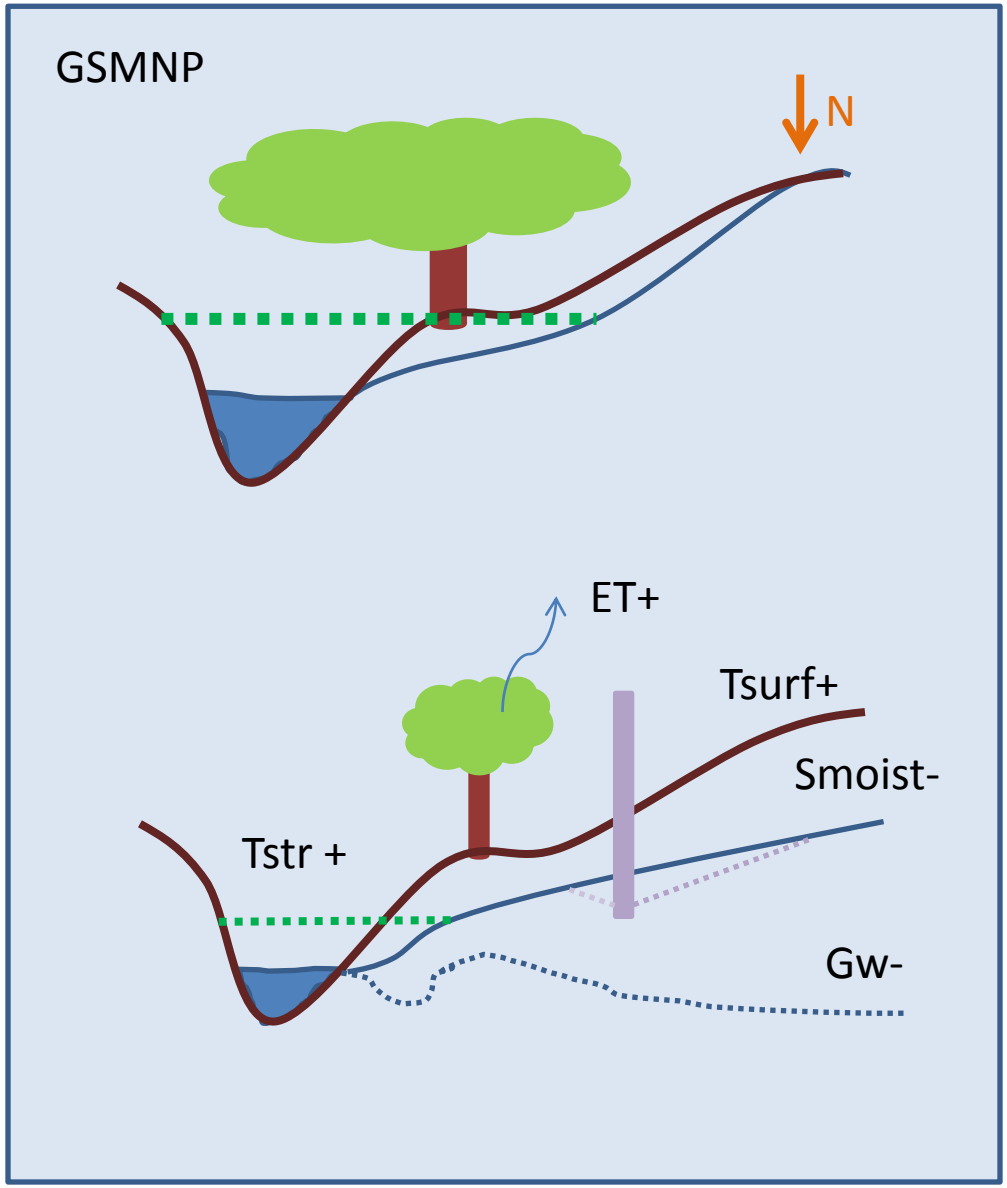
Barros 2012

Landscape Ecology Impacts

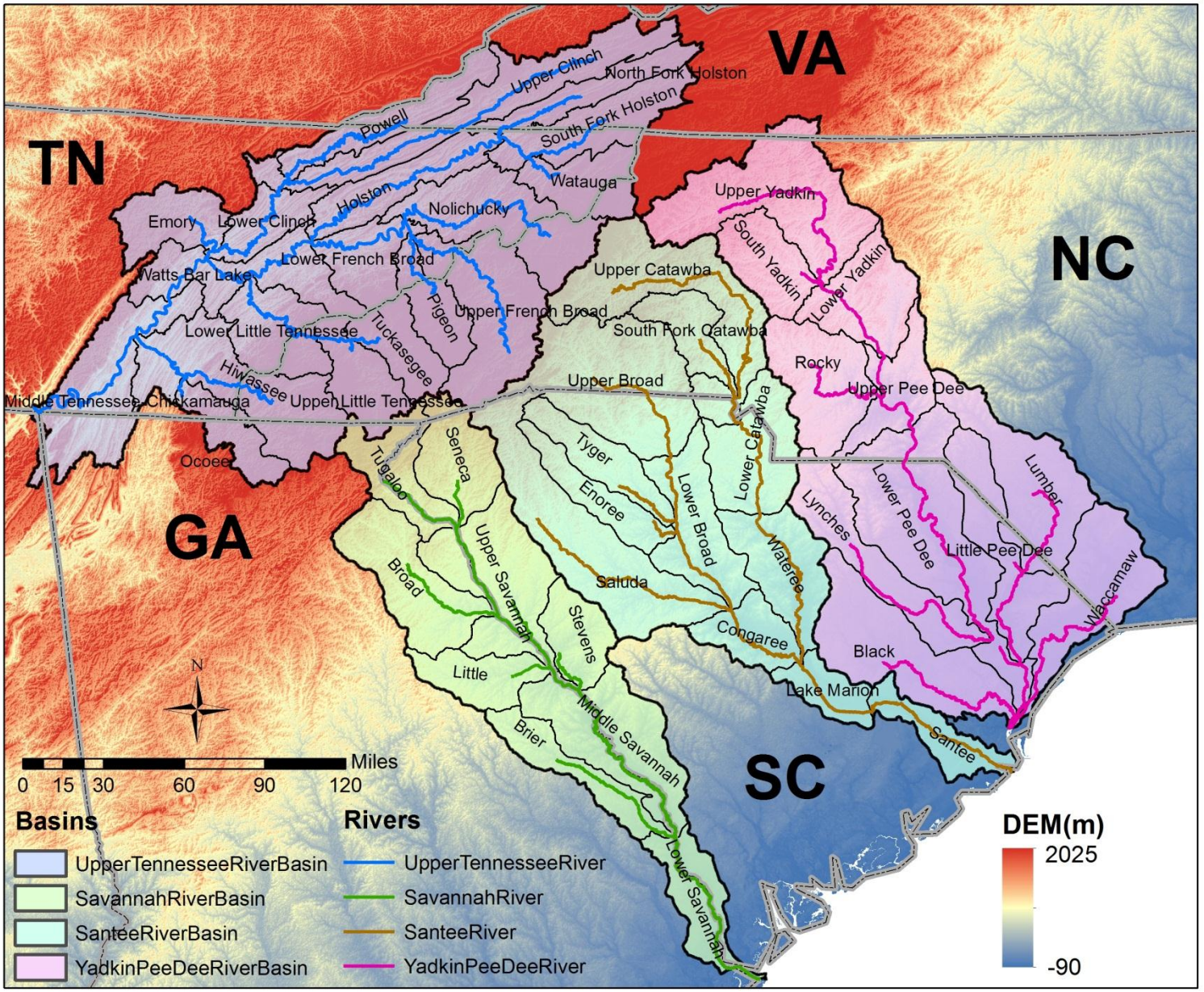
-Landscapes as Throughflow Systems







HMT-SE QPE QFF Intercomparison Project



Conclusions and Discussion

- Water Cycle as a Dynamical Multiscale System of Systems
  - Space-Time Support
- Deliberate Observing Systems
  - Detection and Attribution
  - Action under Uncertainty
- Adaptation and Sustainability
  - Functional Landscape vs Point of Use Perspectives
  - Impacts/ Downscaling
- **"Sweating the Small Stuff"**

References

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